CLAIMS

1. A thermo-optic phase shifter comprising:

a substrate;

a heater;

a clad layer provided directly or indirectly on said substrate;

a bridge section clad layer formed apart from said substrate and said clad layer in a portion corresponding to said heater, said bridge section clad layer being connected with said clad layer in a portion of said phase shifter other than said heater corresponding portion; and

a core layer provided inside said bridge section clad layer,

wherein said bridge section clad layer and said core layer form a bridge section optical waveguide in said heater corresponding portion, and

said heater is provided inside or outside said bridge section optical waveguide apart from said core layer in said heater corresponding portion, and generates heat to change a phase of a light signal propagated in said bridge section optical waveguide.

2. The thermo-optic phase shifter according to claim 1, wherein a distance between said bridge section clad layer and said substrate is equal to or

more than 4 μm.

3. The thermo-optic phase shifter according to claim 1 or 2, wherein said core layer, said clad layer and said bridge section clad layer are formed of glass material containing quartz.

4. The thermo-optic phase shifter according to claim 3, wherein said glass material of said core layer contains germanium.

5. The thermo-optic phase shifter according to any of claims 1 to 4, wherein said substrate is formed of glass material containing quartz or silicon.

6. The thermo-optic phase shifter according to any of claims 1 to 5, wherein said clad layer is formed on said substrate through a sacrifice layer, and

said sacrifice layer is formed of material with an etching rate larger than that of said substrate.

7. The thermo-optic phase shifter according to claim 6, wherein said sacrifice layer is formed of material with a thermal conductivity smaller than that of said substrate.

8. The thermo-optic phase shifter according to claim 6 or 7, wherein said sacrifice layer is formed of glass material containing phosphor, and

said clad layer is formed of glass material containing boron and phosphor.

9. The thermo-optic phase shifter according to any of claims 1 to 5, wherein said clad layer is formed directly on said substrate.

10. The thermo-optic phase shifter according to any of claims 1 to 9, wherein said heater is provided on said bridge section clad layer.

11. The thermo-optic phase shifter according to any of claims 1 to 9, wherein said heater is provided in said bridge section clad layer apart from said core layer.

12. The thermo-optic phase shifter according to claim 11, wherein said heater is provided under said core layer in said bridge section clad layer.

13. The thermo-optic phase shifter according to any of claims 1 to 12, further comprising:

a supporting section provided in a part of

a space between said bridge section optical waveguide and said substrate to support said bridge section clad layer.

14. The thermo-optic phase shifter according to claim 13, wherein a width of a portion of said bridge section optical waveguide where said supporting section is provided is wider than that of a portion of said bridge section optical waveguide where said supporting section is not provided.

15. The thermo-optic phase shifter according to claim 13 or 14, wherein said supporting section is formed of material with a thermal conductivity smaller than that of said substrate.

16. The thermo-optic phase shifter according to any of claims 13 to 15, wherein said supporting section is formed of material of an etching rate larger than that of said substrate.

17. The thermo-optic phase shifter according to claim 13 to 16, wherein said supporting section is formed of a same material as said clad layer.

18. The thermo-optic phase shifter according to any of claims 13 to 17, wherein said supporting

section is continuously formed over a full length of said bridge section optical waveguide in a direction in which said core layer extends.

19. The thermo-optic phase shifter according to any of claims 13 to 17, wherein said supporting section is formed in the portion in a direction in which said core layer extends.

20. The thermo-optic phase shifter according to any of claims 1 to 19, wherein said optical waveguide clad layer has a width wider in ends of said heater corresponding portion than in a center of said heater corresponding portion.

21. The thermo-optic phase shifter according to any of claims 1 to 20, further comprising:

a reinforcing beam provided in grooves between said clad layer and said optical waveguide clad layer on a way of said heater corresponding portion to support said optical waveguide by connecting said clad layer and said optical waveguide clad layer.

22. A method of manufacturing a thermo-optic phase shifter, comprising:

forming a sacrifice layer on a substrate,

said sacrifice layer having an etching rate larger than said substrate;

forming a lower clad layer to cover said sacrifice layer, said lower clad layer having an etching rate smaller than that of said sacrifice layer;

forming a core layer in a predetermined portion on said lower clad layer;

forming an upper clad layer on said lower clad layer and said core layer;

forming a heater in a portion corresponding to said predetermined portion on said upper clad layer;

forming grooves in a portion corresponding to said predetermined portion on both sides of said heater to pass through said upper clad layer and said lower clad layer to said sacrifice layer; and

removing at least a portion of said sacrifice layer through said grooves.

23. A method of manufacturing a thermo-optic phase shifter, comprising:

forming a sacrifice layer on a substrate, said sacrifice layer having an etching rate larger than that of said substrate;

forming a first lower clad layer to cover said sacrifice layer, said first lower clad layer

having an etching rate smaller than said sacrifice layer;

forming a heater in a predetermined portion on said first lower clad layer;

forming a second lower clad layer on said first lower clad layer, a lower clad layer having said lower first clad layer and said second lower clad layer;

forming a core layer in a portion corresponding to said predetermined portion on said second lower clad layer;

forming an upper clad layer on said lower clad layer and said core layer;

forming grooves on both sides of said heater in a portion corresponding to said predetermined portion to pass through said upper clad layer and said lower clad layer to said sacrifice layer; and

removing at least a portion of said sacrifice layer through said grooves.

24. The method of manufacturing a thermo-optic phase shifter according to claim 22 or 23, wherein said removing comprises:

removing said sacrifice layer to form a space between said lower clad layer and said substrate to connect said grooves with each other.

25. The method of manufacturing a thermo-optic phase shifter according to claim 22 or 23, wherein said removing comprises:

removing said sacrifice layer to leave a portion for supporting said lower clad layer in a portion corresponding to said predetermined portion.

26. The method of manufacturing a thermo-optic phase shifter according to claim 24 or 25, wherein said removing comprises:

removing said sacrifice layer by using hydrofluoric acid solution or buffered hydrofluoric acid solution.

27. The method of manufacturing a thermo-optic phase shifter according to any of claims 22 to 26, wherein a film thickness of said sacrifice layer is equal to or more than 4 μm.

28. The method of manufacturing a thermo-optic phase shifter according to any of claims 22 to 27, wherein said forming a sacrifice layer, and said forming a lower clad layer or said forming a first lower clad layer is continuously carried out.

29. The method of manufacturing a thermo-optic

phase shifter according to any of claims 22 to 28, wherein said forming an upper clad layer, said forming a core layer and said forming a lower clad layer are carried out by an atmosphere chemical vapor deposition method or a plasma chemical vapor deposition method.